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THE PROGRESSIVE FISH CULTURIST

NEWS AND VIEWS FROM MANY SOURCES ON PRACTICAL HATCHERY PROBLEMS

2107

ISSUED BY THE

U. S. DEPARTMENT OF COMMERCE

HARRY L. HOPKINS, *SECRETARY*

BUREAU OF FISHERIES

CHAS. E. JACKSON, *ACTING COMMISSIONER*

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THE PROGRESSIVE FISH CULTURIST

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BUREAU OF FISHERIES, U. S. DEPARTMENT OF COMMERCE

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DISEASE PREVENTION IN THE TROUT HATCHERY

Some Observations On Preliminary Experiments with Routine Prophylactic Treatments.1/

By Frederic F. Fish, U. S. Bureau of Fisheries

WITH THE COMPARATIVELY recent evolution of fish hatching into true fish culture, the problems offered by fish diseases have likewise evolved from more or less of a petty annoyance into a first class headache.

Methods for raising fish have changed markedly during the past twenty years, but developments in the treatment of diseases have not kept pace. Most present-day methods merely represent adaptions of the earlier techniques applied, none too successfully, to the modern system of fish culture.. Many a hatcheryman has been correct in his assumption that the beneficial effects following the administration of many treatments were not worth the price that he paid in dead fish involved. It is becoming very obvious that treating diseases is entirely too comparable to padlocking the barn after the horses have been stolen. The logical answer to the fish disease problem as well lies in prevention.

There are several possible approaches to the problems offered by disease prevention in the trout hatchery but only two general methods seem possible at the present time. The ultimate answer unquestionably lies in running a fish hatchery in exactly the same manner as a research laboratory maintains a colony of disease-free chickens, namely, start with uncontaminated eggs and keep diseases out forever thereafter. As fish, perforce, must live in the very medium upon which disease-producing

1/ With the cooperation of the Division of Fish Culture. I am particularly indebted to Messrs. Joe Kemmerich, A. T. Looff, A. Gentry, K. K. King, H. D. Baer and A. Bernier.

organisms are totally dependent for their existence, disease prevention at a fish hatchery through the maintenance of absolute sterility depends upon the complete fulfillment of two basic conditions. A disease-free source of water must be available and, of equal importance, a strict quarantine against any possible introduction of disease-producing organisms must be rigidly enforced at all times.

A disease-free water supply in practically all instances necessitates bacteriological sterilization by one or another of the various physical or chemical processes employed for this purpose. Probably the most practical method for sterilizing the large volume of water demanded in the operation of a fish hatchery is by direct chlorination. Chlorination requires expensive and relatively delicate apparatus for injecting exact quantities of chlorine into the water with a high degree of accuracy. The initial cost for satisfactory chlorinating equipment runs in the neighborhood of $2,000 thus precluding the installation of such apparatus at very many hatcheries. Chlorine is highly toxic to fish life as well as to pest life, hence in addition to the chlorinating equipment, a second set of equipment providing efficient dechlorination must likewise be provided and at an additional cost. Sandwiched in between the processes of chlorination and dechlorination must be ample facilities for storing the water for a minimum period of ten minutes while the gas is at work. As most methods of dechlorination likewise result in partial deoxygenation, the water must be thoroughly reaerated before use - a problem at hatcheries having low water pressures. Chlorination, storage, and dechlorination represent an effective - although expensive - method for assuring a disease-free water supply. This method, however, can offer no protection against subsequent contamination by disease-producing organisms entering the water after it has passed from the dechlorinator.

Maintaining a hatchery free from disease-producing organisms is by no means as simple as it sounds. Even in fish research laboratories supplied with chlorinated city water, fish disease organisms manage to make their unwelcome appearance with amazing frequency. If keeping the troublesome "bugs" out of a research laboratory, where relatively few fish are involved and these subjected to constant scrutiny by trained research workers, is a difficult task, how much more so it would be in the present-day producing hatchery! The water supply is but one of the possible sources of disease at a hatchery, hence all other potential sources must be tightly closed and constantly maintained so before there is much point in investing considerable funds in a chlorinating outfit. The prevention of diseases through the maintenance of sterile technique is practicable in the research laboratory and undoubtedly will become so in the fish hatchery of the future, nevertheless, it is doubtful if the present equipment and methods of operation would justify its attempted application at very many existing hatcheries.

A second alternate method for preventing diseases, less costly, and at present more universally practical in many ways, is the routine application of effective preventative treatments. This method, if successful, would relieve the hatchery personnel of some of the responsibility for maintaining sterile conditions at all times. If effective treatments could be administered at weekly intervals, disease-producing organisms, regardless of whether their source was the hatchery water supply or an incoming shipment of eggs, could only get in six days work before the next treatment would cut their enterprise short. Since few, if any, fish diseases really get under

way within six days after the initail exposure to infection occurs, the disease-prevention problem would boil down to a program of weekly treatments. Such a method for preventing diseases may be excellent in theory, but its realization will depend upon the development of a simple, safe, effective method for treatment which can be applied with a minimum investment of time and effort. Of all the methods of treatment now available which might be used, so-called "prolonged treatments" seem to offer the most promise as prophylactics against the diseases of trout and salmon. Conspicuous exceptions would be Octomitiasis and furunculosis for it is improbable that such treatments could in any way affect the progress of these diseases.

One of the greatest limitations which prolonged treatments now possess is the almost complete lack of information concerning the efficacy and toxicity of the various possible disinfectants or combinations of disinfectants. To determine these characteristics for each disinfectant, one must take into account the interplay of such complicating factors as disinfectant-concentration, temperature, size of fish, and the type of disease with a miscellaneous collection of unknowns such as the chemical composition of the water, accumulative toxicities, species variation, and possible food reactions thrown in for good measure. The many possible disinfectants available for use in prolonged treatments must be individually tested, both in the presence and absence of disease, so that those which prove toxic or fail to meet exigencies under controlled conditions may be weeded out.

Such was the ultimate goal in planning a series of preliminary studies on prolonged treatments made during the past summer by the West Coast Pathology laboratory of the U. S. Bureau of Fisheries. In the absence of large scale equipment wherein fish could be experimentally infected as desired, it was decided as an alternative, to attempt a duplicate series of treatments at weekly intervals using various concentrations of four common disinfectants at three separate hatcheries. If diseases appeared at these hatcheries during the course of experimentation, any beneficial effect of these treatments could be ascertained. If no disease appeared, at least the toxicity of the disinfectant-concentrations used could be established.

Accordingly, at each of the three hatcheries chosen for this experimentation, namely the Bureau's stations located at Birdsview, Quinault, and Parkway in the State of Washington, a battery of ten upper troughs were each stocked with 5,000 blackspotted trout eggs. Treatments were administered to eight troughs, the remaining two in each series being reserved untreated as controls to determine what would have happened in the absence of treatments. With the exception of two troughs at each hatchery which were salted with a predissolved three percent by weight solution of salt for approximately ten minutes, all treatments consisted of the prolonged type administered by the inverted-bottle apparatus. Daily water temperatures and daily losses by actual count were recorded from each trough. In calculating the results, the daily losses were averaged by three day intervals determined by dividing the number of fish dying in that interval by the number of fish present in the trough at the beginning of the interval. By using the three day averages, the confusing fluctuations of daily percent loss were ironed out.

During the period of experimentation, no disease developed at the Mount Rainier hatchery located at Parkway, Washington. A very mild infection of the western type of gill disease developed at the Quinault hatchery and a severe epidemic of the same disease appeared at the Birdsview hatchery.

A. CALENDAR OF EVENTS

QUINAULT HATCHERY

Aug. 18 - Troughs stocked
19 - Hatching started
22 - Hatching completed
23 - "White Spot" disease appeared on yolk of fry in trough 4 and, to a much less extent in trough 8
Sept. 3 - Fish fed - diet 100% liver
12 - Treatments started
19 - 2nd treatment
26 - 3rd treatment
Oct. 3 - 4th treatment
8 - Mild case of western type gill disease discovered on specimens
10 - 5th treatment
17 - 6th treatment malachite green treatments on troughs 1 and 2 subsequently discontinued
24 - 7th treatment
31 - 8th treatment
Nov. 7 - 9th treatment
14 - 10th treatment
21 - 11th treatment
22 - Experiment terminated

BIRDSVIEW HATCHERY

July 23 - Troughs stocked
24 - Hatching started
26 - High losses from crippled fry attended hatching
27 - Hatching completed all troughs other than 7,8,9,10 treated
Aug. 2 - Fish fed - diet 90% liver, 10% Quilcene salmon meal
3 - 2nd treatment including troughs 7 and 8
9 - Fish in troughs 1 and 2 reported as not taking food and becoming pin-headed
10 - 3rd treatment malachite green treatments on troughs 1 and 2 subsequently discontinued
17 - 4th treatment
23 - Western type gill disease discovered on specimens
24 - 5th treatment
30 - Fish in control trough 9 given two hour treatment with boric acid, 1-500
31- 6th treatment
Sept. 7 - 7th treatment
14 - 8th treatment
21 - 9th treatment
28 - 10th treatment
Oct. 5 - 11th treatment
12 - 12th treatment
19 - 13th treatment
26 - 14th treatment

MT. RAINIER HATCHERY

July 26 - Troughs stocked
30 - Hatching started
Aug. 7 - Hatching completed
28 - All cripples removed
Sept. 1 - Fish fed - diet 100% liver
12 - Treatments started
19 - 2d treatment
21 - High losses resulted from feeding of spoiled food
26 - 3rd treatment
Oct. 3 - 4th treatment
11 - 5th treatment
18 - 6th treatment
24 - 7th treatment Potassium permanganate treatments on troughs 3 and 4 subsequently discontinued
31 - 8th treatment
Nov. 6 - 9th treatment malachite green treatments on troughs 1 and 2 subsequently discontinued
14 - 10th treatment
21 - 11th treatment
29 - 12th treatment
30 - Experiment terminated

OBSERVATIONS

Quinault hatchery: The occurence of white spot disease in trough 4, and to a much lesser extent in trough 8 immediately upon hatching (reflected in the high losses in these two troughs between August 20 and 22) is interesting. As the eggs used in this experiment were thoroughly mixed to assure representative samples before the troughs were stocked, it would appear that white spot must have resulted from some condition peculiar to troughs 4 and 8 and was not an infectious disease as it is usually considered, otherwise all troughs should have been affected. What this condition in troughs 4 and 8 may have been is conjectural as too little information is available to warrant any conclusions. The fish in both trough 4 and trough 8 continued to experience abnormally high mortalities throughout the period of experimentation

The losses in all ten troughs continued at approximately the same intensity until the first treatments were administered on September 12. Immediately thereafter, a marked jump in losses occurred in the fish treated with malachite green, copper sulphate, and potassium permanganate.

Malachite green, 1-750,000 for one hour, was obviously toxic under the conditions at Quinault. Potassium permanganate, 1-500,000 for one hour, was likewise toxic and particularly so during the mild outbreak of western gill disease which appeared between October 9 and 14. Copper sulphate, 1-500,000 for one hour, apparently proved somewhat toxic during the latter part of the experiment. It did, however, keep the losses somewhat below those in the untreated troughs during the outbreak of gill disease.

Salting the fish each week did no demonstrable harm although in the absense of any serious outbreak of disease, little can be deduced concerning its possible benefits.

Birdsview Hatchery: The usual increase in losses attended hatching, primarily because of crippled and malformed fish. The losses ran approximately uniform in all ten troughs until the second treatment was administered on August 3 when the losses jumped markedly in troughs 1 and 2 treated with malachite green, 1-500,000 for one hour. The losses continued to mount in troughs 1 and 2 until the treatments with malachite green were discontinued after the August 10th treatment. The losses remained abnormally high in these troughs throughout the entire experiment even though the treatments had been stopped.

A consistent rise in the daily mortality was noted subsequent to August 19 and an investigation of dead fish from all troughs revealed the western type of gill disease to be responsible. The daily losses in all experimental troughs subsequently increased although in troughs 3 and 4 treated with copper sulphate, 1 to 400,000 for one hour the losses were definitely less than those in any other troughs. Copper sulphate treatments did not prevent the appearance of western type of gill disease but did materially alleviate the effects of the disease. Copper sulphate treatments were continued on troughs 3 and 4 after the records shown on the accompanying table closed. As is indicated during the latter part of the experiment as recorded, a 1-400,000 concentration proved definitely toxic.

On August 30, it was decided to test the curative powers of boric acid against the western type of gill disease. Sufficient quantity of this reagent to make a 1-500 solution was predissolved and added to trough 9 as evenly as possible. The inflow was shut off immediately and the water in the trough was then kept aserated for two hours by means of an electrically driven centrifugal pump discharging approximately ten gallons per minute from the lower end of this trough to the upper. A marked drop in the daily losses of this trough followed this treatment although the losses continued to rise in the accompanying untreated control trough 10. In this instance, boric acid, 1-500 for two hours, apparently had a definitely beneficial effect as a therapeutic.

Following the acute stages of gill disease, which extended from August 19 to September 23, the disease slowly worked itself out although the losses remained abnormally high to the end of the experiment.

Chlorazene, 1-100,000 for one hour, proved definitely toxic and in spite of the toxicity of this concentration, it had no effect in preventing gill disease or allaying its effects.

Weekly saltings apparently exerted no beneficial effects in preventing or controlling western gill disease.

Mt. Rainier Hatchery: The usual increase in losses occurred on August 28 when all crippled and deformed fish were removed from all troughs. Aside from this occasion, the losses on all troughs ran uniformly low from the start of this experiment until September 21 when one feeding of spoiled food jumped the losses, some troughs being harder hit than others.

One of the treatments appeared to be toxic until the third application of potassium permanganate, 1 to 400,000 on September 26 caused an appreciable increase in the losses on troughs 3 and 4. The losses from these two troughs continued abnormally high until the treatments with this disinfedtant were discontinued four weeks later following the October 24th application. After the treatments were discontinued, the losses on these troughs fell to a subnormal level - probably caused by the earlier killing of the weaker fish. Malachite green, 1-500,000 for one hour, likewise proved toxic after the fourth treatment.

The losses were but slightly higher on the lots treated with Chlorazene and salt than on the untreated control lots.

At no time during the course of experimentation at the Mt. Rainier hatchery did disease enter as a factor in causing losses.

DISCUSSION

Malachite green proved toxic during one hour weekly exposures to concentrations of 1-500,000 and 1-750,000. Both concentrations proved toxic at the first treatment when water temperatures approximated 56°F. At 44°F, a 1-500,000 concentration was not toxic during one hour weekly exposures until after three treatments had been given. This indicates the importance of water temperatures as a factor for consideration when determining toxicities. No conclusions can be drawn concerning the efficacy of either concentration of malachite green in preventing or controlling the western type of gill disease.

Potassium permanganate, 1-400,000 for one hour, proved toxic after three treatments at 44°F. A 1-500,000 concentration not only proved toxic upon the first application at 55°F, but it definitely failed to prevent a mild outbreak of western gill disease at the Quinault hatchery and furthermore, actually increased the losses attending the outbreak. Whether a weaker, non-toxic concentration might prove more successful is conjectural.

Chlorazene, 1-100,000, did not prove to be significantly toxic during eleven weekly treatments at 43-44°F. The same concentration at 56°F was, however, of no value in preventing western gill disease. Like potassium permanganate, the chlorazene treatments appeared to aggravate the losses attending the outbreak of disease.

Salting by means of a predissolvered percent by weight saline solution for ten minutes did not appreciably increase losses at any of the three hatcheries during the entire period of experimentation. Contrary to the usual belief, saltings proved to be of no benefit in preventing or controlling western gill disease.

Copper sulphate, 1-400,000 for one hour, appeared to become progressively more toxic at the Birdsview and Quinault hatcheries where this reagent was tried. The losses attending the outbreak of western gill disease at both hatcheries were significantly lowered by such treatments with copper sulphate although in neither case did the treatments prevent the appearance of the disease entirely.

A marked drop in the daily losses followed a two hour exposure to boric acid, 1-500, after western gill disease had gained a solid foothold. This is the first instance wherein any form of treatment has appeared of value in combatting this particular disease. Even though boric acid apparently exerted a strikingly beneficial effect upon western gill disease and possibly may prove to be a valuable prophylatic and therapeutic, nevertheless, it is no "cure-all". In separate experiments, in no way connected with those reported herein, boric acid 1-500 treatments for two hours failed completely to lower either the subsequent daily mortality or the average number of parasites per fish attending an experimental infection with the protozoan parasite Cyclochaeta.

CONCLUSIONS

At the present time, the routine application of prolonged treatments appears a promising method for preventing many diseases among hatchery fish. The series of prophylactic treatments reported herein were all "shots in the dark" and many of the disinfectant-concentrations chosen proved toxic. These experiments did eliminate potassium permanganate, chlorazene, and saltings as being of any promising value in preventing the western type of gill disease. They likewise indicate that the routine application of copper sulphate in non-toxic concentrations may be of considerable value in allaying the effects of this disease.

These experiments represent a very short step down the long road leading to effective disease prevention at trout hatcheries. Much more progress must be made before any definite conclusions can be drawn. However, the present outlook does indicate that this road will reach the desired objective and will not prove to have a blind ending.

FOURTH ANNUAL MIDWEST WILDLIFE CONFERENCE

By Dr. A. S. Hazzard, Director Institute for Fisheries Research
Ann Arbor, Michigan.

INFORMALITY WAS the keynote of the Midwest Wildlife Conference which was held December 8 to 10 at Columbus, Ohio. This was the fourth annual meeting of fish and game technicians—an organization without constitution, by-laws or officers. First called by Dr. T. H. Frison, Director of the Illinois State Natural History Survey, the purpose was to bring together all those interested in wildlife research and management for free discussion of methods and results. The Conference includes the eight North Central States: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio and Wisconsin. Visitors from other states and from the federal offices in Washington are welcome.

Nine states and the District of Columbia sent 154 delegates to the Columbus meetings. After registration the conference broke up into the following sections with discussion leaders chosen by the conference: Farm Game – Dr. Lawrence Hicks, Ohio; Forest Game - R. R. Hill of Wisconsin, and Fish – Dr. Albert S. Hazzard of Michigan. At the banquet Friday evening the discussion leaders summarized the papers presented in the three sections for the benefit of the conference and visitors. The principal address was given by Ohio's Commissioner of Conservation Larry Wooddell on "The Application of the Results of Research in a Conservation Program". Saturday was devoted to field trips to points of interest in Ohio.

The Fish Management section was well attended (we moved to a larger room after the first session). As is customary, the work of the state where the conference was held received greatest emphasis. Dr. Langlois opened the program by outlining the organization and progress of fish management work in Ohio. Each of the eleven fish management agents talked briefly on the problems of greatest importance in his district. As Ohio has few natural lakes and only one trout stream of importance, fishing is mainly confined to warm water streams and reservoirs. Checking soil erosion and silting by better watershed control and maintaining water levels by the use of small dams were considered fundamental to improved fishing. Control of pollution was also shown to be essential in certain areas. Extensive drainage apparently has been an adverse factor in maintaining fish supplies at least in the northern half of the state. Creation of fishing lakes by damming headwater streams offers promise in some districts.

Ohio's fish planting program was discussed by Harold Waskco, in charge of the state fish farms. This was of especial interest in that each fish management agent (primarily a regional biologist) prepares the stocking plan for his district based upon his surveys and observations and takes and active part in the program of distribution. He must also pass upon the desirability of local stream improvement work and may initiate such programs.

In common with many other states, Ohio is faced with the problem of insuring public access to fishing water. The approach to this difficult problem was discussed

by William E. Owens, engineer for the Division. The approach is unique in that the improvement of the property to be leased by the state is considered at the time negotiations are undertaken for the easement. Proposed fencing, construction of stiles, posting, bank erosion control and installation of small dams all in exchange for public access to the stream help to make the program successful. Some 2100 easements have been secured to date, 57 small dams have been built and other improvements to leased property were accomplished by 5 stream improvement units. Sportsmen's organizations and civic groups have helped by supplying materials but most of the labor has been hired by the Division. The dams constructed are low (none exceed 42 inches), are carefully designed and solidly built. Their purpose is not to impound a large area but simply to keep the old channel filled. This work is exceedingly popular among fishermen and the demand for such service greatly exceeds the present capacity of the units. Any who are interested in further details of this program are referred to recent issues of the Ohio Conservation Bulletin, official publication of the Division of Conservation.

The operation of test net crews by the Ohio Division as described by George Messerly was also of considerable interest. These crews engage in fish rescue and transfer work but when not needed for such work set trap nets and seine public waters in various localities. Frequently this helps to convince sportmen that fish are present in their local waters even though they may not be able to catch them. The crews cooperate with the local fish management agent in supplying fish for tagging, distribution studies and life history investigations.

Results of fish tagging in Ohio were discussed by E. L. Wickliff of the Division's Research Bureau. Apparently the movement of fish planted in Ohio streams is almost entirely downstream. The suggestion was made by Dr. Thompson of Illinois that according to his experiences wild fish would not exhibit such a marked tendency.

Ohio is fortunate in having an able fish parasitologist located at one of its colleges in the person of Dr. V. Bangham, who spoke on the ecological distribution of fish parasites. In general his findings showed that most parasites were of greatest abundance in western Ohio and were less numerous in streams than in lakes.

A striking illustration of the effects of deforestation and drainage was given in a paper by Milton Trautman, formerly of the Ohio Division. Change from conditions favorable to the production of game fish to conditions intolerable by such species was shown by his survey of fish populations in the same streams studied by the pioneer ichthyologist Seth Meek fifty years ago.

Relatively little discussion of hatchery problems occurred during the conference. However, the analysis of labor expenditure in six Indiana fish hatcheries by Mr. John Gottshalk proved very interesting. This study showed that most operations were conducted as efficiently as possible considering the physical handicaps at certain stations which were improperly designed or located. An interesting conclusion was that maintenance of grounds and buildings cost on the average a little more than did the actual production and distribution of the fish. This is something for fisheries agencies to keep in mind when planning additions to their hatchery systems. It was also found that size of the hatchery is important in considering its efficiency; a 2

to 5 acre plant costs as much to operate and produces many fewer fish than one of 15 or 20 acres. Propagation of pond fishes by the extensive method only was considered in this analysis.

A report of trout feeding experiments in Michigan hatcheries was made by James Wilkinson. The results parallel those of Embody, Davis, McCay and others in demonstrating that the use of dried supplements to fresh meat diet (the best combination appeared to be 30% fresh sheep liver, 20% fish meal, 20% cottonseed meal, 10% oatmeal and 20% skim milk powder) reduced the cost of rearing trout to fingerling size by approximately one third. However, in the Michigan experiments, the use of the dried meals resulted in somewhat slower growth than secured by the use of straight meat. The amount of silt present in the water supply was shown to be a factor in feeding meat and meal mixtures which tend to sink more rapidly than meat alone and become lost to the fish if pond bottoms are heavily silted.

Dr. David Shetter presented tentative conclusions from plantings of marked fingerling trout in which returns to the angler's creel varied from 0 to 1.6% of the number planted. The conference was unanimous in agreeing that experiments designed to demonstrate the actual benefit to the fishermen of planting fish of different sizes were urgent in order to make the best use of the sportsman's dollar.

Fish predator studies in Michigan were discussed by Karl F. Lagler. Stomach analyses of common fish predators collected around hatcheries and rearing stations were presented in graphic form. Although usually considered harmless, stomach studies of garter snakes were shown to contain young game fish. Results of experiments in controlling predatory birds by other means than killing were presented. It was pointed out that the cost of present control methods at trout rearing stations might pay for the installation of effective screens for raceways. The need for more investigation in developing such control methods was stressed.

Evidence continues to accumulate that year marks (annuli) should not be called "winter rings". Dr. Donald Hansen demonstrated that in Illinois waters annuli in the crappie and in the largemouth bass do not appear until early summer and that there is a marked variation in the time of formation depending on the age of the fish. This is an important consideration in growth rate studies of fishes.

A series of unusual pictures was used by W. F. Carbine to illustrate his studies of the spawning habits of centrarchid fishes in a small Michigan lake. An attempt was made to count all the nests of each important game species, to determine duration of spawning season, average production of fry per nest and various relationships between spawning and non-spawning individuals. Partially completed counts of fry indicate that enormous numbers of fry of bluegills and lesser numbers of other species are produced in this lake. Fry from 8 bluegill nests were counted, yielding an average of 23,188 young fish. If the figure is representative of the 369 bluegill nests observed in this ten acre lake, the total production of fry would be 8,556,372.

Fish yield studies on several artificial lakes in Iowa as reported by W. W. Aitken were interpreted by him as demonstrating a correlation between stocking and yield at least in some species. Combining records for three years for Lake Wapello, the percentages of species stocked and caught were respectively: Largemouth bass 33%

and 9%; crappie 12% and 10%; bluegills 45% and 45%; bullheads 8% and 36%. A ratio of 3.5 to 1 exists between the number of fish planted and the total number caught by anglers. It would be extremely valuable if this study could be continued and if the stocking could be varied from year to year in order to determine more exactly the benefits derived.

Data on actual fish populations of five Illinois lakes were presented in graphic fashion by Dr. David Thompson and George Bennett. The figures showed that the largest number per acre of game and "fine" fish were found in lakes containing neither forage fish (such as minnows and gizzard shad) nor coarse fish (buffalo and carp). The heaviest population of bass was found where the only other fish present were bluegills. Dr. Thompson's explanation was that since a body of water can produce only a limited poundage of fish, adult forage fish and coarse fish utilized food and space which would otherwise be available to game and "fine" species (crappies, bluegills and catfish) and were too large for these fish to eat. Even the young of these fish were not fully available to the young of more desirable species as they soon outgrew them. These population studies further demonstrated a standing crop of fish in Illinois lakes varying from 250 to 1145 pounds per acre.

Presenting Dr. Frison's discussion of Fox Ridge Lake, an Illinois Natural History Survey fisheries management project, Dr. Thompson stated that it was their conclusion that improvement in fishing in Illinois depended upon increasing the number of places to fish. Their creel census studies showed that Illinois fishermen will not ordinarily travel more than 30 miles to reach fishing water in the state. Since so many of the larger streams are polluted or are otherwise unsuitable for sport fishing, the solution seems to lie in constructing many small, artificial lakes by damming streams of small or intermittent flow. Fox ridge Lake is an experimental project of this sort recently completed and designed to demonstrate the best possibilities of this idea. Various methods of fish management will be tested on this lake under rigidly controlled conditions.

A program of winter lake sounding and mapping in Michigan was described by Dr. C. J. D. Brown. This is designed to secure maps of bottom contour and soil type in lakes which cannot be mapped through CCC cooperation. The development of a portable electric ice drill was described. The use of this drill should greatly decrease the labor necessary for rapid sounding by a small crew.

Uses of rotenone in fisheries management was discussed by Dr. J. W. Leonard. Concentrations necessary in Michigan waters and in laboratory experiments were found to vary with the species of fish, water temperature and water hardness. The values and the danger of this "tool" in management were considered by the Conference.

Dr. Samuel Eddy presented some results of a cooperative study of a number of Minnesota lakes. A fish poundage range of from 25 to 340 per acre was estimated as a result of seining some 20 acres in each lake. An important conclusion reached as a result of these surveys was that heavily fished lakes contain many more fish per acre than those which are lightly fished but contain relatively few old and large individuals. Dr. Eddy's explanation of this phenomenon was that the larger fish had been removed by angling and since they form the natural check on the number of young, the heavily fished lakes rapidly become overpopulated with small fish because of too successful survival of the young of the year. If this be true, the common practice of

stocking heavily fished lakes with fingerling bass, bluegills and other warm water species on the theory that these lakes need most planting because they are heavily fished is a serious error.

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In general the trend of discussion in the Fish Management Section seemed to question most the present methods of management. The need for experimental waters where old methods could be accurately tested and new methods devised was constantly emphasized. The importance of population studies in management was stressed repeatedly. Population control is coming to be regarded as the most promising of the new methods which have been suggested for the improvement of fishing in warm water lakes.

(Editor's Note: The brief summary of papers given was based on personal notes. Quotation is not advised without verification of the author cited.)

FEEDING OF MONTANTA GRAYLING AT THE BOZEMAN, MONTANA STATION.

By Charles L. Fuqua, U. S. Bureau of Fisheries,
Bozeman, Montana

THE MONTANA GRAYLING has been aptly described as one of the most attractive and gamey of the fresh water fishes. Jordan and Evermann (1904)1/ have the following to say relative to this fish: "As to game qualities, Dr. Henshall regards the Montana grayling as fully the equal of the brook trout or red-throat trout, putting up a good fight and often leaping above the surface when hooked. It takes the artificial fly, caddis larva, grasshoppers, angleworm and similar bait." Such a species is deserving of continuance, and, in order that it might be more widely propagated, fish culturists for the past thirty years have devoted thought and effort to some method of feeding that would allow the raising of fingerling and adult fish.

Much of the effort during the past few years has been devoted to the feeding of this fish by natural foods consisting of plankton gathered from lakes and other bodies of water. Such feeding of natural foods met with apparent success, but to the fish culturist engaged in the propagation of fish for stocking public waters, this method was extremely impracticable. The writer has for a number of years been interested in finding a suitable method of feeding this species of fish, and during the summer of 1936 Regional Director of Fish Culture, Fred J. Foster, gave me permission to experiment with a number of the grayling at the Spearfish, South Dakota, Station of the Bureau of Fisheries, where I was then in charge. Ten thousand eyed eggs of this species

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1/ Jordan, D. S. and Evermann, B. W.
1904. Fishes, Nature Library, Vol. IV.
Doubleday, Page & Co.

were hatched and the resulting loss from June 13 (the date the eggs were received) to January 1, amounted to 3,462. The result of this small experiment gave rise to the desire to conduct the artificial feeding of the grayling still further. This paper gives a brief outline of the results obtained in this work during the years 1937 and 1938.

In the past when these fish were planted only as fry, the problem of their wide distribution was very difficult. It was necessary to plant the young fish within a day or so after hatching, at which time the fish were very delicate. The mortality of such fish after planting was extremely great and the transportation problem was complicated. Also, it was impractical to stock any number of bodies of water within such a limited time. The raising of fingerlings is necessary in order to supply applications and stock numberous bodies of water throughout the distribution season.

Many experiments have been conducted in the past in the artificial feeding of the Montana grayling. Probably the first work of this kind was conducted by Henshall (1907)2/ at the Bureau of Fisheries Station at Bozeman, Montana. Henshall has described the artificial feeding as follows: "It was found that fresh blood supplied before the yolk sac is entirely absorbed answers a good purpose. Liver emulsion rendered as fluid as possible, and then strained through ordinary muslin, will serve to tide the fry over the precarious stage until they are a month or six weeks old, when they can be fed the same as trout fry. During the first stages they must be watched closely and fed much more frequently than trout fry. If fresh blood can be procured, and stirred until it becomes a homogeneous fluid free from clots, it can advantageously be supplied either straight or mixed with the strained liver emulsion. But, owing to the very small size of the grayling fry, artificial feeding is under all circumstances quite a problem. At the Bozeman station they have been reared to maturity in the manner mentioned with a loss of from 50 to 70 percent, and the mature fish have been stripped and the eggs hatched and fry planted."

This extremely heavy loss (50 to 70 percent) was entirely too great to allow for the raising of fingerling grayling for distribution on a large scale. Therefore efforts toward artificial feeding continued throughout the years. Notable attempts were made in Montana and at other points.

The Steinhardt Aquarium in San Francisco experimented for several years with the feeding of this fish. Montana Wild Life Magazine (1930) quoting Mr. Seale3/ has the following to say relative to their work: "On May 19, 1924, we received at the Steinhardt Aquarium about 4,000 grayling eggs in eyed condition. They were placed in the hatchery, and by May 30 they were hatched. As soon as the food sac was absorbed we began feeding through a cloth, powdered shrimp, meat juice, sour milk curd, fresh fish ground to a powder, liver and beef heart. None of these could be regarded as a success and the death rate mounted rapidly. Within four months every one of the young graylings were lost."

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2 and 3/ Seale, A. S.
1930. Montana Grayling Calif., Editorial
Montana Wild Life.

In the East, graylings have been hatched and reared to maturity in the hatchery by Laird4/ at the Southside Sportsmen's Club, Oakdale, Long Island and by Lord5/ at the Bureau of Fisheries Experimental Hatchery, Pittsford, Vermont. In both cases the fry were first fed beef liver ground as fine as possible and later fed practically the same diet as trout.

It will be noted that in these early efforts, foods of a fluid nature were used. Such types of foods have not been considered satisfactory by the writer because of the tendency to cause the water to become murky, the lack of well defined particles of food, and the loss by leaching out of valuable food substance. Beef heart was decided upon as probably being the most suitable food and has been continued throughout.

The experiment of feeding larger quantities of the Montana grayling was carried on during the season of 1937 at Bozeman, Montana, the writer having been placed in charge of the Bureau of Fisheries Station at that point. During the month of June 100,000 eyed grayling eggs were secured from the Bureau's spawning station at Grebe Lake in Yellowstone Nation Park. These eggs were hatched in troughs at the Bozeman station in every way similar to the methods used with trout. The resulting loss of fish through the year was not extremely large, 79,486 fish having been planted or transferred to other stations, and 5,450 fish lost due to the water supply of a trough shutting off. These fish ranged in size from one inch to five inches.

Several thousand fish five inches in length were planted during the spring months in the West Gallatin River. Many fish, ranging in size from 6 to 10 inches, were reported caught throughout the summer. The balance were distributed to Forest Service waters, and other waters within the state.

The work of 1936 and 1937 having proved so successful, 250,000 eggs of this species were allowed for conducting the work during 1938. On June 24, 1938, 250,000 eyed eggs were received from the Grebe Lake spawning station. Half these eggs were placed in water of 50 degrees and the other half in water of 55 degrees. Both lots completed hatching July 3. These fish were carried in this manner until July 21. With the exception of water temperature all other conditions such as feed and handling were identical. However, the mortality in the 50 degree lot was almost double that of those held in the 55 degree water. Although these fish were too small at this time to readily make a comparison in size, it was apparent that those in the 55 degree water were doing much better, that it was decided to place the entire lot in water of 55 degrees. An exception was made of two troughs as it was decided to carry these as a further experiment. The water in one of these troughs was increased to 60 degrees and the other continued at 55 degrees. The loss was practically the same in the two small experimental lots from July 21st until the conclusion of the experiment on September 30th.

4/ Laird, James A.
1928 Grayling in the East. Transactions of the American Fisheries Society, vol. 58, pp. 167-169.

5/ Lord, Russell F.
1932 Notes on Montana grayling at the Pittsford, Vt. Experimental Trout Hatchery. Transactions of the American Fisheries Society, vol. 62, pp. 171-177.

The feeding of the entire lot of fish was carried on from the second day after hatching. Beef hearts were used exclusively. For the first seven days the hearts were ground thirty times through a meat chopper plate having 1/64 inch openings. The meat was put through the chopper until it started to become warm; then placed in the refrigerator until cooled off, and then put through the chopper the balance of the required number of times. The meat was then fed to the fish by shaking it through a brass sieve having 50 meshes to the inch. Feeding was started at 7: A.M. and continued throughout the day at one hour intervals until about 7:00 P.M. After seven days a screen having 40 meshes to the inch was used and this was changed after six days to one having 30 meshes to the inch. After the fish had developed to a size large enough so that they could readily take food which had been put through a 20 mesh screen, for a period of several days, the screens were eliminated altogether. The entire period over which the screens were used amounted to 28 days. As fast as the fish increased in size so as to take larger particles of food, the number of times the meat was put through the chopper was cut down. After the screens were eliminated feeding was accomplished by the use of a spoon and the meat was put through the chopper only eight times. At this stage the number of times per day the fish were fed had been cut to five.

During both 1937 and 1938 beef liver was tried for limited periods of time, but in all instances the mortality increased rapidly and the feeding of this meat was stopped immediately. While beef heart in itself is not a balanced ration for grayling it will certainly provide suitable food for the first two months. During 1937 hearts were fed for only one month, but it has seemed to be good policy to feed hearts for at least two months before entering into a more balanced diet such as mixtures containing salmon carcass meal, seal meal, kelp, beef liver, beef spleen, etc.

The writer believes that the success of feeding this species of fish in the hatchery depends to a very great extent on the proper attention shown to the job by the particular employees doing the actual work. If the employees assigned to the job will make a diligent effort to properly feed the fish at intervals of one hour for the first two weeks, see that the food is well distributed over the water so that it may be readily taken by the fish, see that the food is properly ground and put through a screen of a suitable mesh, there will be little or no difficulty in raising the grayling in large numbers with only slightly more loss than one would expect with a lot of trout. It is entirely possible that some local condition may in some way effect the feeding of the grayling, but it is the writer's opinion that for the most part the painstaking care that is exercised in the feeding of these fish for the first two or three weeks is the controlling factor.

An examination of stomachs of grayling fry has shown that although the fish attempt to take food within a day or so after hatching, they probably do not actually take the food into their stomachs for several days. In feeding these fish at Bozeman we have made it a point to start feeding within two days after hatching in order that the food would be available when needed. No adverse results are derived from such action, and it appears advisable to continue this, although this matter will bear further investigation.

After the fish have passed the first month of their lives, their further care is comparatively easy. They are very voracious and will overeat to the extent that they

will endanger their lives if the food is given to them. Their growth rate varies greatly within the same lot and it is necessary to grade them often. They give little or no trouble either in troughs or ponds and require less attention than trout of the same size. They carry well during transportation, fish having been taken from this station to be planted in high mountain lakes by pack horse, some transported to distant parts of the state by tank trucks, and others having been shipped via the Bureau's railroad cars.

It seems that the splendid results secured from feeding these large quantities of grayling fingerlings warrants further investigation and experimentation with these fish. Experiments in the raising of this species in relation to water temperatures, effect of light on their growth rate, effect of different foods on their growth and mortality, and their comparative growth rate with trout should be made. The experiments conducted during the past two summers have of necessity been very limited due to lack of time that could be devoted to such work. The Bozeman station is engaged during the summer months in raising a large number of fingerling trout for distribution to public waters, and the personnel is not sufficiently large to allow for any more than very limited experimentation. It is hoped that as time goes on we can learn more about the factors involved in the propagation of the Montana grayling. It is entirely possible that this fish may be found to be adaptable to warmer waters which are now devoted to less desirable species. The grayling appear to have less natural aptitude than the trout, and are much more readily caught by the angler, thus causing them to be more quickly depleted in waters where there is intensive fishing.

A brief summary of the results of the work conducted during the summer of 1938 is given below. The losses were kept with care, and the figures are as nearly correct as it was possible to make them.

250,000 eyed grayling eggs received on June 24, 1938

125,000 placed in water 50 degrees

	LOSS	
Date	Eggs	Fing.
June 24 - July 2	2,300	
July 3 - July 15		2,841
July 16 - July 21		230

125,000 placed in water 55 degrees

	LOSS	
Date	Eggs	Fing.
June 24 - July 2	2,225	
July 3 - July 15		940
July 16 - July 21		192

Total loss on entire lot from arrival of eggs to July 21 8,728

Both lots combined on July 22, 1938 and placed in water of 55 degrees.

Total number of fish on hand July 22, 1938, was	241,272
Loss from July 22 - 31	1,005
On hand end of month	240,267
Loss from August 1 - 31	3,619
Planted	97,900
On hand end of month	138,748
Loss on entire lot from arrival of eggs to end of hatching period	4,525
Loss on entire lot for first 30 days after hatching	5,426

Of the two troughs of fish caried in water temperatures of 55 and 60 degrees, the loss between the two lots from July 21st to Septem er 30th was within a few fish of being equal. The growth rate of the fish held in water of 55 degrees was the difference between 460 per ounce on July 21 and 33 per ounce on Septem er 30. The growth rate of the fish held in the 60 degree water was the difference between 460 per ounce on July 21 and 23 per ounce on September 30.

An Editorial

C R E D I T T O W H O M C R E D I T I S D U E

WITH THE ISSUANCE of the last number (No. 42, November-December, 1938), THE PROGRESSIVE FISH CULTURIST completes four years of service to the active fish conservationists of the country. Our readers who still have copies of the first issue of December, 1934 and who have received the intervening issues can observe the progressive development and improvement in the character and scope of the subject matter.

One thousand copies of the first issue were printed and offered to the public but before many months, owing to the continued requests for back issues by new subscribers many of the earlier numbers were reprinted in order to furnish complete sets; even these long since have been exhausted. In recent months the mailing list has continued to grow at the rate of approximately 50 per month and during the month of January of this year 67 new names were added. Three thousand copies of the August-September number were printed. Only a few remain for filing and binding.

Probably every fish cultural station in the United States and most of them in Canada receive the journal; every conservation commission or fish and game commission in the United States receives it; a great many instructors and professors in universities and colleges use it for class references, and a number of clubs and city libraries have it on their shelves. Aquiculturists and administrators in foreign countries because of special services or courtesies shown or special demands, although the number is small, also receive the journal. The countries represented include Australia, Brazil, England, France, Germany, Japan, New Zealand, Norway, Palestine, Scotland, and South Africa.

Owing to the fact that THE PROGRESSIVE FISH CULTURIST is produced upon a very slender budget, the Bureau has been concerned with the increasing expense of a growing mailing list. In the October number the readers received a questionnaire with a return coupon permitting those who still wish to receive the journal to request the continuance of their names on the list. It was hoped that in the interest of economy those who had left the fish cultural services or had entered other fields of activity would fail to reply or would indicate that the journal was no longer desired.

The final tabulation of the new mailing list from these replies has not yet been completed but it is plainly evident from the volume of the requests received that the journal is serving the interests of aquiculture well enough to be highly appreciated by the recipients. While a few have been dropped from the mailing list, in many cases

the coupons were returned with additional names so that actually no material saving in printing costs will be possible.

While the coupons bearing the statement, "Continuation on this mailing list is (or is not) desired", were as a rule filled out in a simple matter-of-fact way indicating the wishes of the signer, a surprising number were returned with various voluntary comments written in on the margins or attached. There was remarkable unanimity in these comments. Thirty-two of them for sake of emphasis filled in the space with such works as: "Is much desired", "Is very much desired", "Decidedly is desired", "Is by all means desired", etc.

Comments on the margins ran as follows, to quote a few examples: "I value the magazine very highly." "The paper is very instructive in our studies." "I find it very interesting and useful and should miss it very much." "I place high value in your publication." "I find it very interesting and educational." "I am extremely anxious to continue on your mailing list. I frequently have occasion to make use of this material." "I own one of the largest fish hatcheries of its kind in the world and naturally want to continue receiving THE PROGRESSIVE FISH CULTURIST." "It would be hard to get along without THE PROGRESSIVE FISH CULTURIST. I keep it on file all the time and use it as a reference book."

Occasionally such comments as the following were received: "Nice going", "Keep the good work going", etc.

A goodly number enclosed letters of commendation with their coupons. Here are a few examples:

From Ludington, Michigan, "I enclose the coupon to re-register me for THE PROGRESSIVE FISH CULTURIST. This magazine used to great advantage in work of the conservation club of this city. The articles appearing in each issue are discussed at meetings and we have done some very fine stream improvement using your bulletin as a guide. Please continue this paper as it is used to great advantage in a group of 250 members."

From Twin Butte, Alta., "I am very grateful for THE PROGRESSIVE FISH CULTURIST. It is the most important book-of-the-month to me and I sincerely hope that the Bureau will be able to continue its publication for a long time to come."

From Albany, Oregon, "I have taken great interest in the articles of THE PROGRESSIVE FISH CULTURIST because of the practical nature of the material printed in it. I believe that THE PROGRESSIVE FISH CULTURIST is superior to many textbooks used in fishery courses at universities and colleges -- but professors get royalties on their textbooks."

From Troy, Montana, "This publication is a valuable asset to any fish culturist, whether a beginner or an old, experienced hand. I would gladly pay a fair price for continuance of this publication annually."

From Toronto, Canada, "THE PROGRESSIVE FISH CULTURIST is a most useful source of information and I find it valuable for myself and my men to keep in touch with current events and thought in the field of fish culture. It has a very prominent place in our library and is always read by several of the men before it is even taken off the table I wish very much to be kept on your mailing list."

And so on and on, to the number of 102 individual replies, none of which are from Bureau employees.

Now all of this is very gratifying indeed to the Bureau of Fisheries and to the Editors. But, how much the service would be improved if even those who have written such notes of generous praise would also, when in the writing mood, present brief articles, notes, observations, opinions, or discoveries that could be published in future numbers.

The Editors take no credit to themselves for the features of the paper that have evoked such stimulating praise except as they have contributed individually to our pages. Rather are they but the vehicle for conveying to our readers the collective fish cultural skill and wisdom of our CONTRIBUTORS. Let our CONTRIBUTORS be assured, therefore, that their efforts are appreciated. May their good work continue.

The Editor.

FOUNDERS OF FISH CULTURE

MARSHALL MCDONALD, 1835 - 1895

By Dr. William C. Kendall, Freeport, Me.

IN A MEMORIAL by Prof. A. J. Malgren, Inspector of Fisheries of Finland, addressed to the Bureau of Agriculture of the Imperial Senate for Finland, January 20, 1883, in regard to the advisability of introducing artificial fish culture in that country, Marshall McDonald was named as one of a number of Americans who had "become famous in the annals of pisciculture, partly by new discoveries in the technical part of fish hatching, partly as practical pisiculturists of patrons of pisciculture".1/ This was about five years after Colonel Marshall McDonald was appointed as Fish Commissioner of Virginia.

The Fish Commission of Virginia was established in 1874 with two Commissioners who, in 1875, were replaced by three other men. In 1878, McDonald was appointed Fish Commissioner of Virginia, which now became a one-man commission. Until 1880 his address was given as Lexington. After that until 1886 it was Berryville. From 1887 on, his residence was stated as Washington, D. C.

That McDonald was familiar with fish cultural practices before he was appointed Fish Commissioner of Virginia, is indicated by the fact that in 1876, he was put in charge of a hatchery which had been established in connection with the Virginia Military Institute, where he was to give instruction in fish culture.

1/ The others cited as deserving mention were: Livingston Stone, Seth Green, T. B. Ferguson, C. G. Askins, J. Williamson, W. G. Halton, F. W. Clark, J. H. Slack, F. Mather, R. E. Earl, H. C. Chester, and "above all" Prof. Spencer F. Baird.

The site selected for the purpose was easy of access from the Institute and from Washington and Lee University, where there was a spring having a temperature of 53°F., and water enough for 200,000 eggs of the California salmon and double that number of brook trout. After completion of the building, of 160,000 salmon eggs received 3,500 were dead when the boxes were opened. By the 26th of October the balance were "laid down". By the 8th of November all but 4,000 of them were hatched. Of these 5,000 were accidently killed, 6,000 died after hatching, 1,500 were malformed, leaving about 140,000 fry in the troughs.

In his report to the Commissioners of Virginia McDonald said:

> "I have not lost sight of the fact that a prime object in establishing a hatching house in connection with the Institute was to furnish facilities for training experts in the important art of pisciculture, but the press of construction and handling has not allowed time for instruction as yet.
>
> "If the Commission proposes to send eggs of the brook trout to be hatched this winter, I will be able to begin formally the work of instruction and experiment."

The report of the U. S. Commissioner for 1878 regarding shad-hatching operations on the Atlantic coast, said that McDonald made a station at Tobago Bay, near the mouth of the Roanoke River, and hatched out 1,960,000 fish between the 3d of May and 1st of June. All of these were placed directly in the Roanoke. He said, "It is anticipated that the shad can not fail to make their presence known within the next three or four years."

In the winter of 1879-80, McDonald was associated with R. Edward Earll in a tour of the South Atlantic States in the interest of the U. S. Census and the U. S. Commission of Fish and Fisheries. Earll gave special attention to the marine fisheries, while McDonald was particularly concerned with the river fisheries of the southern seaboard with special attention to the freshwater fishes and more important anadromous species such as the shad, alewife, and sturgeon.

McDonald evidently collaborated to some extent with Earll for the latter says that he and McDonald had excellent opportunities for examining the spawning condition of Spanish mackerel and proving that the theory advanced by (Genio C.?) Scott to the effect that this fish spawned in the waters of the Atlantic States in the spring was more nearly correct than that advanced by Prof. G. Brown Goode, who "ventured the assertion" that it probably spawned in mid-winter in the Gulf of Mexico and about the West Indies. Earll and McDonald found it spawned along many portions of the Atlantic coast in mid-summer. Previously nothing had been known concerning the breeding habits of this fish.

Earll wrote that a further investigation of the subject proved that the Chesapeake was an important spawning ground for the species and that the spawning season continued during the greater part of the summer. He said that Colonel McDonald at once communicated these facts to Professor Baird by telegraph.

In the summer of 1881 a station was established at Cherrystone, Va., on the eastern shore of Chesapeake Bay a few miles above Cape Charles, for the purpose of making

a further study of the Spanish mackerel. At first the work was conducted by Lieut. Z. L. Tanner, Commander of the Fish Commission steamer Fish Hawk and later by Colonel McDonald and Prof. J. A. Ryder.

On June 17 operations were commenced and up to the end of the fiscal year 1,130,-000 eggs were taken and 366,000 fry released. They were not very successful in finding ripe fish, in explanation of which fact, Col. McDonald advanced the opinion that Cherrystone was too near the Capes and that the mackerel required warmer water for the full development of their eggs.

In his report upon this investigation McDonald said that in August he visited Tangier Island and Crisfield. Here he had an opportunity to inspect the mackerel boats fishing off Tangier Island, all of which ran to Crisfield in the morning after a nights fishing. In one boat which had two or three hundred mackerel, he found 52 fully ripe fish, which, he said, would have yielded over 5,000,000 eggs, a number larger by far than were obtained from the pounds near Cherrystone during the entire season.

Fishermen informed him that the height of the spawning season was from the middle of June to the first of July. He considered it probable that the Middle Ground off Tangier Island was the breeding place and recommended that, if artificial propagation of the mackerel was to be undertaken, a station be established at or in the vicinity of Tangier Island and that the Commission operate its own pounds, which could be fished whenever and as often as convenient.

His investigation and recommendation seem to have been overlooked, ignored, or forgotten, for in 1883, Dr. Albin C. Kite reported upon investigations by the Fish Hawk in that year, and, basing his recommendation for a station site, upon information obtained from James A. Smith, an officer of the Fish Hawk, he said, "There is no more favorable spot than at the mouth of Cherrystone Creek".

In 1876 McDonald was delegated by the Fish Commissioners of Virginia to visit the Centennial Exposition at Philadelphia, with instructions to make a careful study of the models of fishways there exhibited, with the view of finding one adapted to the ascent of shad in the James and Rappahannock Rivers. His quest proved a failure.

Several years after this unsuccessful visit to the Centennial Exposition in search of a model of "efficient shadway", McDonald set about devising one himself. About 1881 or 1882 one of his design was constructed on the Rappahannock River near Fredericksburg, Va. which, in 1883, McDonald said had been in successful operation two seasons.

Another built in the winter of 1882, on the Potomac River, near Shepperdstown, W. Va., he reported had "given full satisfaction to those who had watched its operations. Black bass and other river species had been observed to pass "in numbers and with ease." This fishway was far above the Great Falls of the Potomac, beyond which shad could not pass, therefore shad could not have been included with the "other river species".

Still another fishway erected at Bosker's Dam on the James River, nine miles above Richmond, was in operation since the middle of May, 1883. This was said to be

a later and improved design, though embodying the same principles of construction of the Fredericksburg fishway. After the water was turned on all the river species except shad were observed passing in large numbers. However, very few shad had reached the dam that season, the total catch by nets being less than two hundred.

These fishways are described and figured in an article by McDonald under the title: "A new system of fishway-building" in the Report of the U. S. Fish Commission for 1882 (1884). The signed article is dated August 25, 1883.

In his report for 1882, U. S. Commissioner Baird said that numerous forms of fishways have been more or less successful, especially in connection with the movements of salmon, but that such fishways had not been successful in facilitating the upward run of shad, and in spite of a great deal of ingenuity and much expenditure of money and experiment, the problem could not be considered entirely solved.

However, he stated that a device of Col. Marshall McDonald, one of the principal assistants of the United States Fish Commission, held forth very great promise of success, and that it was proposed to test the apparatus at the Great Falls of the Potomac, Congress having made appropriation for the purpose.

Again in his article on the status of the U. S. Fish Commission in 1884, G. Brown Goode wrote that salmon had profited much by fishways in Europe, and that the immense dams in American rivers would doubtless be passable even for shad and alewives if the new systems of fishway construction by Colonel McDonald, which were then being applied on the Savannah, James, Potomac and other large rivers, fulfilled their promises of success.

In 1885, a plan for a fishway over Great Falls was suggested by McDonald and necessary working drawings were adopted and recommended to the Secretary of War for such further action as he might think proper. In the summer of that year a contract was given out by the Secretary of War and the work on its construction begun.

In the report of the Commission, for the year ending June 30, 1898 (1899), in his appended report in "The Shad Fisheries of the Atlantic Coast of the United States" Charles H. Stevenson, referring to the fishway at Great Falls, says that in 1882 an appropriation of $50,000 was made by Congress for the erection of a suitable fishway at Great Falls, and in 1885, the work of construction was begun. The plans provided for a fishway in six sections in the Maryland channel. A high freshet during the night of October 29-30 considerably damaged the partly completed sections, and after examination it was decided that "the fishways were not planned sufficiently strong to withstand the effects of the violent floods of the locality in which they were placed" and the project was abandoned.

In his "Report (Bull. U. S. Fish Comm. for 1887 (1889) upon the results of salmon planting in the Hudson River", Fred Mather refers to a fishway built at Troy by "The McDonald Fishway Company". He said that this form of fishway differed in principle from all others, and from a study of fishways in Europe and America he believed it to be the best in use. From a study of working models he was satisfied that the McDonald fishway was the easiest of ascent of any. It is not certain that the McDonald mentioned in this report was Marshall McDonald.

The first attempts at artificial propagation of fish in this country were with some species of salmonids. The apparatus used was more or less like that employed in Europe, but often original in construction and application. It was later found desirable to extend efforts at propagation to other species, the eggs of which varied greatly in character and required widely different treatment. Salmon and trout eggs were relatively large and "heavy" and the incubation period was of comparatively long duration. On the other hand shad eggs were minute and semibuoyant. The incubation period was very short. Other species, such as the cod and mackerel had floating eggs. Still others had adhesive eggs, and so on.

The fish culturists with inventive turn of mind set about to devise apparatus adapted to hatching the eggs of the fish with which each one was particularly concerned. Numerous devices were tried some of which were defective, some more or less successful, and some complete failures. Most of the more successful of these systems had their drawbacks. With whatever device used or whatever the character of the eggs, there was the ever present problem of getting rid of the dead eggs, which were subject to attack by fungus with its deleterious effect on the living eggs.

With the large eggs of salmon and trout during the long incubation period, it was comparatively easy, although entailing much tedious work, to fish out the dead eggs by hand. But with the small eggs of the shad and other species, the incubation periods of which are very short, it was another story.

The United States Fish Commission first attempted to hatch cod eggs at Provincetown, Mass., and later at Woods Hole, but with poor results.

The technical ingenuity of McDonald had early attracted the attention of Commissioner Baird, so, in November 1880, having submitted to the Commissioner plans of an apparatus which he thought would be adapted to hatching of the floating-eggs of the cod, McDonald was directed to proceed to Woods Hole, there to conduct experiments with his apparatus.

The experiments were carried on during the early part of the winter. Concerning them McDonald reported that the range of investigation was limited from the fact that during the time that he was there only a single lot of spawning fish was obtained. While from these some millions of eggs were secured, the larger part of them was lost and only some four or five thousand fry were hatched.

The apparatus that he had proposed was an inverted funnel, the lower end of which dipped below the surface of the water contained in a trough, upon which it rested, the supply of water being brought in by a tube at the upper or smaller end of the funnel, so that when once filled with water the column was maintained by the pressure of the air. The apparatus worked very well for a few days but from increase of specific gravity of the eggs or some other reason the eggs were carried out and lost.

At a later time McDonald invented an apparatus in which there was a rise and fall of the water, which proved a success. This he called the tidal-hatching box. The apparatus is still in use at Woods Hole and at Booth Bay Harbor for hatching cod eggs. The manual of fish culture, published that year, says, "The apparatus now in general use is the so-called McDonald or automatic tidal box. The boxes are constructed in

series of 12 or less, the number depending on the size of the hatching room, the arrangement of the hatchery tables, or other conditions."

The first apparatus to be used in hatching shad eggs was the Seth Green hatching-boxes, which, though subsequently improved in several ways, were never fully satisfactory. The boxes containing the eggs were anchored in the stream. It was practically impossible to adequately separate the dead from the living eggs. Consequently fungus developed and only a small precentage of any of the eggs hatched.

Subsequently metal cones, invented by Bell and Mather were employed, but the same difficulties obtained with this apparatus. Some modifications aimed to effect the separation were made by F. N. Clark but to no avail. Clark also attempted to modify the Chase hatching jar, with the result that he concluded that an "automatic self-picking" apparatus for the complete separation of dead from living eggs was impracticable. However he managed a partial separation by syphoning off the dead eggs and transferring them, with such loose living eggs as were necessarily drawn off with them, into other jars which he called "hospital jars". Here the living eggs thus drawn off were left to chance hatching. In this way the loss of eggs from fungus was greatly reduced and a large percentage was hatched.

In 1881, for the propagation of shad on the Potomac, two large barges, one fitted as quarters and the other with facilities for hatching, were transferred from Havre de Grace and anchored at Gunston Bay, about 20 miles below Washington. In his report for that year the Commissioner said that this temporary shad-hatching station was most successful and was under the immediate direction of Mr. Marshall McDonald from April 20 to May 30 inclusive.

While McDonald was in charge of this station, he was not satisfied with the methods there in use. He, therefore, experimented with several devices aimed at the complete separation of the dead from the living eggs. He based his experiments upon the difference in specific gravity of the dead and live eggs. His first experiment was with a sort of trough, which worked fairly well when the barges were still. Next he tried a bowl which was an improvement, but neither trough nor bowl could be applied satisfactorily in practice.

For sometime Professor Ryder had been carrying on experiments to determine the limit of healthy retardation of the development of shad eggs by lowering the temperature of the water. Later in the season, at the suggestion of the Commissioner, McDonald volunteered to assist him in his experiments, which were conducted in the basement of the Smithsonian Institution.

McDonald describes his part in the experiment as follows:

> "In order to subject the eggs conveniently to the action of the current of cold water they were placed in small two-ounce laboratory flasks, closely corked. Through the center of the corks was passed a glass tube which descended to within a short distance of the bottom of the flask and through which the current of water was admitted to the apparatus.****
>
> "An exit tube, the lower extremity of which extends a short distance below the neck of the bottle, provided for the escape of the water. Whilst this form

of apparatus had been devised by me in connection with experiments in retardation above referred to, I had no sooner fixed upon the apparatus than I felt at once I had arrived at the solution of the question of automatic separation of the dead from the living eggs. An eight-ounce wide-mouth glass jar, such as used in the National Museum for holding alcoholic specimens was fitted up.****

"Six thousand shad eggs were placed in this apparatus and a current of water turned on and regulated. The movement of the current established a regular rolling, boiling motion on the eggs, which brought all in succession to the surface. The dead eggs remained there, forming, as they were freed from the mass a layer upon the upper surface of the others. By pushing down the exit tube a suitable distance I found that the dead eggs were taken up by the escaping current, and swept out, leaving an absolutely clean mass of live eggs in the jar.

"The lot of eggs were successfully hatched and at the time of hatching not a dead egg was found in the bottle, nor do I think a live egg was lost in the whole course of the experiment."

Thus was born the McDonald automatic hatching jar, which to a great extent revolutionized the technique of hatching semi-buoyant, and to some extent, eggs of another character. Its birth certificate was issued in September 1882 as a patent for a "method and apparatus for hatching fish", to Marshall McDonald and Stephen C. Brown of Washington, D. C.

In discussing the efficacy of the hatching jars, Professor Ryder called attention to the non-development of fungus, saying that they could be kept so thoroughly free from dead eggs without a skim-net, nd circulation could be so perfectly regulated as to keep every egg in continuous movement, thus preventing any fungus spores from lodging on the eggs. He explained that the continuous and gentle attrition of the ova in the jars effectually prevented any fungoid germs from adhering to the membranes of the ova.

He pointed out that another advantage offered by the glass jars was the ease and accuracy with which the number of eggs could be estimated by graduating the jar into intervals indicating spaces occupied by single thousands of eggs or by measuring the height of the column of eggs in the jar with a graduated rule indicating similar quantities.

In his report of shad distribution for 1886, McDonald recounts the experiences in attempts to stock Pacific coast waters. He said that in 1886 an unsuccessful attempt was made to transfer shad from the Atlantic to the Pacific coast. Detentions on the way consumed so much time that the fry were all lost. In order to guard against loss by delay enroute, the next shipment consisted of eggs as well as fry. They were conveyed by a specially equipped Fish Commission car, which was furnished with tanks and a steam pump for circulating the water.

He said that two stands of McDonald jars with specially designed glass aquaria for collecting and holding fry, completed the equipment of the car as "a moving hatchery". The car left Havre de Grace, May 9, with 1,000,000 young shad, 200,000 eggs on trays, and 335,000 eggs in the McDonald hatching jars. The fry were transported with a loss of 50 percent, while the eggs on trays were all lost. The 385,000 eggs in jars hatched and were planted in the Williamette River, with a loss of less than 10 percent.

By trial McDonald hit upon a means of transporting shad eggs for considerable distances. Concerning this Ryder said that it was thus proved that the transportation of ova by the dry method immediately after they had been water swollen was possible, and that it would answer for long distances. Necessity was the mother of this contrivance, as, in the experiments conducted by Ryder in Washington in 1881 in which McDonald assisted, it was found necessary to devise some ready means of transporting the ova from the spawning grounds over twenty miles down the Potomac to Washington.

In 1881 a method of transporting and hatching white perch eggs was devised by McDonald and described as follows by Ryder: "The eggs were taken on cotton yarn, which was drawn up through a funnel into which the eggs and milt had been squeezed from the spawning fish. The cord, covered with the adhering eggs, was then wrapped upon a wooden reel and sent under cover of damp cloths to the Central Station, where they arrived in fine condition, almost every egg being impregnated." This he said was another adaption of the dry method of carrying the ova of shad. He said that after reaching Central Station, the cotton cord, with the adhering white perch eggs, was cut into lengths of 10 to 12 inches and suspended in the glass hatching jars, and that the development progressed normally as long as not interfered with by the growth of saprolegnious fungus.

While the McDonald jar was developed and perfected in connection with propagation of shad, it was found adaptable to eggs of other species.

In a circular of the German Fishery Association, Berlin, December 2, 1882, an article by Herr Von Behr, on Five American Salmonidae in Germany, states that for two winters large numbers (250,000 to 300,000) of eggs of whitefish, "Coregonus albus", had been successfully shipped to Germany from the United States. He wrote: "The artificial hatching of this fish, which is highly prized in the United States, and which in our opinion is closely related to our 'Marane' has in America reached a very high degree of perfection. Enormous numbers are hatched in numerous piscicultural establishments, the one at Northville, under the direction of Frank N. Clark, annually producing 15,000,000 to 20,000,000. The hatching of the exceedingly small coregonus eggs, and separating of the spoiled eggs from the healthy ones, had hitherto been an almost insurmountable difficulty with us; but in America this is managed in a most ingenious manner, the never-resting inventive genius of the American having produced a series of apparatus - one more ingenious than the others - which leaves the separating of the spoiled eggs from the healthy eggs to the gentle force of an exactly regulated current, a self-picking system.

"Quite recently Messrs. McDonald and Brown have taken out a patent for such a self-picker, which will be described in a future circular."

The apparatus has been used in the hatching of white fish, pike-perch, white perch, yellow perch, and even the buoyant eggs of the cod, and for the hatching of lobster eggs.

In his discussion of the non-development of fungus on eggs hatched in the McDonald jar, Ryder (1881) describes how the notoriously adhesive eggs of the white perch were hatched, and how the development of fungus might be overcome. He indicated that the white perch eggs were one of the most troublesome to deal with practically.

It seems that these adhesive eggs were taken on cotton yarn and Ryder suggested that if these strings with ova adhering to them were hung in the jar, into which a quantity of shad eggs had been introduced it was probable that the attrition of the shad eggs against the perch eggs would prevent the latter being infected.

As late as 1888, in an article entitled: "The Most Recent Methods of Hatching Fish Eggs", William F. Page wrote: "The purpose of this article is to attempt to establish a proper basis for the work of hatching fish eggs. The writer believes that a large measure of success can be achieved by the use of the McDonald universal automatic hatching jar for the developing of not only semi-buoyant but heavy fish eggs. The results of my experience and observation during the past seven years are herein embodied.

"At the Central Station of the U. S. Fish Commission and other hatcheries the following species have been successfully hatched in this apparatus: Shad, whiteish, brook trout, California trout, Rangeley trout, lake trout, Atlantic salmon, and landlocked salmon."

The Commissioner's Report for the year ending June 30, 1889, states that between the 30th of April and the 26th of June, 3,059,000 lobster eggs were taken from 330 females; 1,574,000 were hatched from these and planted in the vicinity of Woods Hole. The hatching apparatus used were the Chester inverted jar, the McDonald improved hatching box, and the McDonald hatching jar, the latter being the most successful.

In his comprehensive paper on "An Exposition of the Principles of a Rational System of Oyster Culture, together with an Account of a new and practical Method of obtaining Oyster Spat on a scale of Commercial Importance", John A. Ryder refers to an apparatus devised by McDonald in which adherent fry was obtained, "to our delight and astonishment", 24 hours after fertilization.

The experiments were conducted in 1882 by Professor Ryder and Colonel McDonald using a "closed circuit system" devised by the latter.

In 1886 when the Fish Commission schooner GRAMPUS was equipped, there was included a device invented by McDonald, designed to keep alive, develop and hatch ("if necessary") such floating eggs of pelagic fishes as might be taken by tow-nets.

It consisted of an ordinary iron-bound bucket ten inches high, thirteen inches in diameter at the top and about 11¾ inches diameter at the bottom, with staves ⅝ inch thick, and coated on the inside with asphaltum. It was provided with an iron bail and fitted inside with two perforated wooden diaphragms; one of which was placed near the top of the bucket and the other about 1½ inches from the bottom, each resting on a wooden flange screwed to the inside of the bucket. In each diaphragm were nine holes, one of which was in the center and the others encircled it. These holes were fitted with glass tubes two inches in diameter and seven inches long. The holes in the lower diaphragm were provided with flanges upon which the tubes rested. When in use the eight around the side of the bucket had their ends covered with cheesecloth so that while the escape of eggs would be prevented, there would be no hindrance to the proper circulation of water. In the center of the bucket was placed an automatic syphon so arranged that when it was connected with a hose bringing water into the bucket, it

would break the flow when it had reached a certain height and would thus cause a regular ebb and flow or "tide motion".

When the floating eggs were obtained, the necessary number of buckets would be put in operation, and the eggs immediately put in the glass tubes where they could be kept in a condition of development until the vessel reached one of the coast stations where the eggs would be put in hatching troughs at the station.

Early in December of 1881, McDonald was instructed by the Commissioner to take charge of the "Division of Distribution" and to "inaugurate, systemize, and perfect" the more economical methods of distribution rendered practicable by the reduction in the cost, size, and weight of the shipping packages.

McDonald had demonstrated that German carp could be transported in a limited supply of water in much smaller and lighter containers than the heavy cans previously used. His device was a covered tin bucket having a capacity of 4 quarts. Aeration was provided by punching several holes in the cover of each bucket. Where a number of buckets were to be sent to one destination, for convenience in handling and better safety in transmission, light crates were prepared, each having a capacity of 16 buckets, and weighing about 100 pounds. The shape of the crates permitted several to be stacked upon each other so that 1000 fish could be carried on a floor space not greater than that required by two ordinary transportation cans, such as had been previously used.

In his report on shad distribution for 1887, McDonald wrote: "The most important experiment to the acclimatization of shad in new rivers was made in connection with the hydrographic basin of Great Salt Lake. This inland sea would seem to present all the conditions necessary for the reproduction of shad under natural conditions. The value that would arise to the inhabitants of that section of the country from the introduction of some anadromous species like the shad in their waters was so evident, that it was determined by Professor Baird, the Commissioner, to test by an exhaustive experiment the capabilities of these waters to supply the necessary conditions. Accordingly car No. 2, with 1,000,000 was sent to Utah and the fish successfully planted." (The operation was successful but the patient died.) "The deposit was made in the Jordan River, it being deemed better to concentrate all the fish in a single plant than to distribute them in smaller numbers to tributary streams of Utah Lake. It is in contemplation to repeat this work in two successive seasons."

This seems to be a good example of early inconsiderate fish-cultural zeal in "acclimatization".

Herr Von Behr wrote in circular No. 8, 1882, of the German Fishery Association, Berlin, after discussing five American Salmonidae in Germany, said: "There are other problems which have to be solved, relating to the sterlet and the shad. The last mentioned fish may well be termed the old flame of the German Fishery Association and it must be said that the attempt to transplant the shad from American to German waters has been carried on in the most energetic manner. Quite recently Col. M. McDonald one of Professor Baird's most active assistants, seems to have shown his intention of making new experiments in transporting shad to Europe. I look to his experiments with great confidence, in the fact that the proud English adage 'Where there's a will there's a way' is no where better understood and practiced than in the United States."

An investigation of the menhaden fishery by a subcommittee of the U. S. Senate, begun in 1882, was continued in 1883. McDonald was designated to represent the Fish Commission. On July 10, he reported to Senator Lapham, chairman of the committee, at Washington, and accompanied the committee in its investigations of the fisheries of the Atlantic sea-board from the Capes of the Delaware to Portland, Maine.

In the comprehensive "Fisheries and Fishery Industries of the United States", edited by G. Brown Goode, 1880, the waters reported upon by McDonald are stated to be: The rivers of eastern Florida, and South Carolina; the rivers and sounds of North Carolina; Chesapeake Bay and its tributaries; Delaware, Hudson, Connecticut, and Housatonic rivers, and minor tributaries of Long Island Sound. Also the fisheries of Virginia.

In May, 1885, by request of the Commissioners of the District of Columbia, McDonald was directed by Commissioner Baird to investigate the pollution of the Potomac River, by refuse from gas factories in relation to its effect on shad.

In the same year he had direction of the fish cultural exhibit at the World's Industrial and Cotton Centennial Exposition at New Orleans.

The Report of the Commissioner for 1887, says that McDonald, acting under instructions from Prof. Baird, made an exploration of the Ozarks region of southwest Missouri, with the object of ascertaining a suitable site for a fish-cultural station where the propagation of species of fish suited to the streams of Missouri, Arkansas, and Kansas, could be conducted to advantage, and thus adequate provision made for a section of the country too remote from existing stations of the Commission to be supplied from them.

After completing his investigation, McDonald submitted a report to the Acting Commissioner, Dr. J. H. Kidder, recommending the selection of a site in the suburbs of Neosho, Missouri, "for reasons fully set forth in the report".

According to the report of the Commission for 1887, immediately after the death of Professor Baird, at the request of the President, Dr. G. Brown Goode, Assistant Secretary of the Smithsonian Institution, assumed the Commissionership and performed the duties of the office for a period of about six months, until the law was modified and McDonald was appointed.

The Act amending the old law under which the Commission of Fish and Fisheries was established, provided: "that there shall be appointed by the President by and with the advice and consent of the Senate, a person of scientific and pracitcal acquaintance with the fish and fisheries to be Commissioner and shall receive a salary at the rate of five thousand dollars a year, and shall be removable at the pleasure of the President. Said Commissioner shall not hold any other office or employment under the authority of the United States or any State." The Act was approved by the President January 20, 1888, and Marshall McDonald was appointed Commissioner.

McDonald's accomplishments and experience while Commissioner of Virginia and during the period when he collaborated with the U. S. Fish Commission and later was connected with it, according to the records, qualified him in conformity to the require-

ments of the law for the appointment. Perhaps there were other candidates and perhaps the fact that he was a Southern Democrat may have influenced President Cleveland to appoint him. Nevertheless President Cleveland's successor, President Harrison continued him in office.

With his appointment as Commissioner, McDonald's career as an active fish culturist was practically at an end, although he retained personal supervision of fish-cultural operations until he could establish satisfactory direction of the work under the superintendence of an assistant.

Yet with all of his administrative work, he couldn't wholly divorce himself from experiments and improvements. In his "Report of Operations at the Laboratory of the U. S. Fish Commission, Woods Hole, Mass., during the Summer of 1888", Dr. John A. Ryder, who had charge of the laboratory that season, said:

> "The Commissioner, Professor McDonald, has been engaged, during a considerable part of the time which he had been able to spare from his official duties, in devising improvements in the methods of displaying living objects in the aquaria under the best conditions. This has been accomplished by allowing the light to pass down through the water from above and cutting off the view from the upper surface entirely. This, with tastefully arranged rock work, algae, polyps, and a limited number of fishes, gives a picturesque effect of marvelous beauty, and also renders the organisms confined in the aquaria capable of being studied under conditions natural to them.****
>
> "The Commissioner also has been experimenting, with most promising results, with new methods of aeration, so as to maintain life in the aquaria without change of seawater. The presence of the water supply in the tanks is utilized in such a way as to form an aerating apparatus which carries a stream of air divided into fine bubbles through some the the aquaria, or such as are fed by constantly renewed supplies of seawater. A plan such as this will make it possible to have marine aquaria operated at the Central Station at Washington, the aeration of the salt water being easily effected by utilization of the supplies of fresh water used in the operation of fresh-water aquaria. This will make the station doubly valuable in conducting experimental work and give increased interest to the display of fresh-water fishes, to which it will then be possible to add many marine forms for exhibition in the living state. This may be made a most important display to the exhibits in the zoological garden to be established in Washington under the direction of the Smithsonian Institution. The fresh-water and marine aquaria, the great national museums of art, science, medicine and anatomy, the great libraries, botanical and zoological gardens situated near together will thus doubtless become centers of great public interest and afford a most useful educational influence in Washington."

A footnote in the Report of the Commissioner for the year ending June 30, 1894, on page one says:

> "Note. - The operations of the Commission during the period under consideration were under the direction of Commissioner Marshall McDonald, whose declining health, however, prevented him from preparing a report covering them. His death occurred September 1, 1895."***

COMMENTS FROM OUR READERS

ARTIFICIAL FOOD FOR BREAM

EDITOR, THE PROGRESSIVE FISH CULTURIST

This office has been frequently requested to advise the best mixture of artificial fish food for bream and other species of sunfish.

The Orangeburg, South Carolina, station has been feeding the following mixture for sometime and has found it to be very satisfactory. This food is produced at rather low cost by simply mixing dry shorts with ground beef hearts.

In preparing the food no definite quantity of shorts is used with a given poundage of ground beef hearts or other meat which may be mixed with the shorts. A sufficient amount of shorts is mixed to form a coating on the meat particles. This coating also gives the meat particles additional buoyancy, which enables the fish to consume practically all of the food before it settles to the bottom.

The wheat shorts used have the following analysis:

Protein.....	Not less than 15. %
Fat.....	" " " 3.50 %
Carbohydrates....	" " " 57.50 %
Fiber.....	Not more than 5.50 %

This material costs approximately $1.50 per hundred pounds at Orangeburg, South Carolina.

It appears to furnish a very reasonably priced food and is much superior to stale bread and other ingredients usually fed to pond fishes. It is not advocated as a food for bass.

Glen C. Leach, Chief
Division of Fish Culture
Washington, D. C.

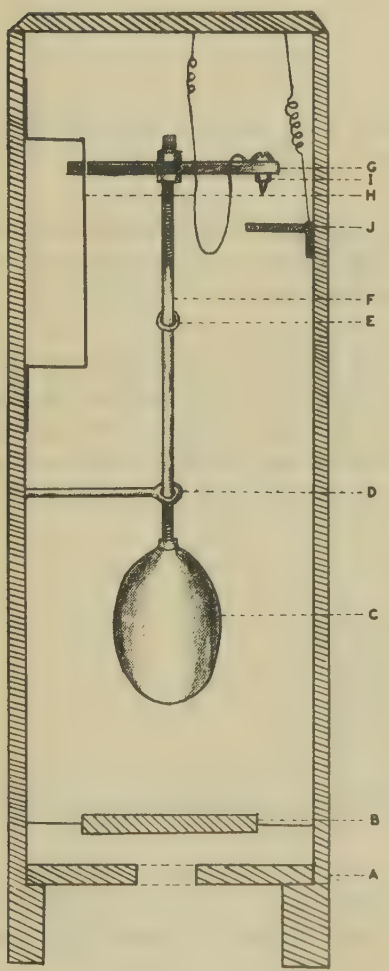
ELECTRICAL ALARM FOR INDICATING CLOGGED TRASH RACK

EDITOR, THE PROGRESSIVE FISH CULTURIST

The Davidson River Trout Rearing Station is located, as the name implies, on the Davidson River which is a rather precipitous stream. The Station receives its water

supply from this stream and problems are present that are unknown to the average fish culturist since most hatcheries receive their water supply from springs which do not fluctuate to any great extent in temperature and flow of water.

Due to the heavy rainfall during the spring and summer months, often several inches of rain falling in a shower of about two hours duration, the Davidson frequently becomes a roaring torrent in a very short time. The water pours down the mountain sides into the small tributaries and into the river, washing a large amount of debris, consisting of leaves, limbs of trees, decayed wood and vegetable material into the main stream. To keep this debris from entering the pipe line a trash rack was constructed at the dam which is 300 yards above the nursery site. Trash lodges on the rack to such a large extent that the water may be completely cut off. The well worn path to the dam indicates that the rack receives considerable attention, especially during rainy weather, it often being necessary to remove the trash hourly for several successive days. The water tmperatures are relatively high for rearing trout, and unless assured of a continual flow of water the fish would not survive long as they would soon consume the available supply of oxygen.



A danger which occured twice during the past two years of operation was a heavy rainfall or cloudburst on the watershed above the station causing the river to rise almost to flood stage with no rain at the station itself. The writer was awakened by the roaring of the river on both occasions and upon examining the ponds found nearly all of them not receiving the necessary amount of water. Had he failed to be awakened a sad sight would have greeted him the next morning; stagnant ponds with thousand of dead trout five and six inches in length.

To prevent the possible loss of fish during rainy weather an electrical alarm device placed in the supply flume has been constructed which will ring an ordinary doorbell in the residence to awaken or remind the man in charge that the trash rack requires attention.

The device consists of a wooden box 8 inches square, one side being hinged, serving as a door so that adjustments of the apparatus may be made. Water enters the box from the bottom through openings in the sides passing through and around baffle boards (a) and (b). This eliminates the waves in the box that are present in the flume. The ordinary toilet float (c) is held in position by brass rods (d) and (e), the ends of which were bent to form an eye just large enough to allow rod of float (f) to slide up and down with ease. Rod of float (F) has a piece of bakelite (g) one inch wide and five inches long fastened to it with two nuts and lock washers. Wire guide (h) passes

through hole in bakelite preventing the float from rotating. Brass screw (i) is sharpened having one end of electric wire attached to it, the other end being connected with electric doorbell. Copper plate (j) is screwed to the inside of the box with wood screws the proper distance from the point of screw (i). Rod of float is slotted at the upper end so that the bakelite plate may be raised or lowered according to the water level. Copper plate (j) has electric wire soldered to it the other end of the wire being connected to three dry cell batteries connected in a series. Thus when trash rack at the dam becomes covered with debris and the water supply is cut down, the water level in the flume drops lowering float which completes the circuit by screw (i) coming in contact with copper plate (j) which rings the bell.

Reuben O. Knuth
Fish Culturist, In Charge
Pisgah Forest, N. C.

A FISH CULTURIST'S PROBLEMS

EDITOR, THE PROGRESSIVE FISH CULTURIST:

Am enclosing the blank asking if I wanted the PROGRESSIVE FISH CULTURIST. I surely do, would be lost without it.

In regard to the FISH CULTURIST, why couldn't we have more discussion of the more practical problems, or am I an exception and others don't have practical problems? I don't know how it is in other parts of the country, but in this part, for every hatchery that raises many fish, there are a couple men like myself who raise the fish for eggs in either natural or artificial lakes, and have very little hatchery operation outside of the eggs and a few thousand fish for restocking purposes.

I have several problems and I would like to know what experience others have had with them. They are:

1. Control of water lilies in a shallow lake and on spawning beds.
2. Advisability of putting forage fish into a trout lake. This is a small (40 acres) shallow lake, with rainbows only, used as spawners.
3. Types of lake and stream fish traps.
4. Water filters for hatcheries.

A. C. Playfair,

Chewelah, Wash.

NOTES AND NEWS

DISTRIBUTION HIGHLIGHTS IN PENNSYLVANIA

(Reprinted from the "Pennsylvania Angler", Vol. 8, No. 2, February, 1939)

DURING 1938 your hatcheries reached an all time high for production in number and pounds of fish produced. When you consider the size and age of the fish, we feel there are very few, if any, States in the Union, equaling the record.

COMMONWEALTH OF PENNSYLVANIA
BOARD OF FISH COMMISSIONERS
Harrisburg

Fish Stocked in the Waters of Pennsylvania—1938

SPECIES	SIZE	AGE	NUMBER
BROOK, BROWN AND RAINBOW TROUT	6" to 21"	10 to 48 Months	1,396,072
BROOK, BROWN AND RAINBOW TROUT	FINGERLING		3,205,475
BLACK BASS	1" to 16"	2 Mo. to Adult	526,608
PIKE PERCH	Fry to 16"	Fry to Adult	7,081,069
YELLOW PERCH	Fry to 10"	Fry to Adult	163,092,418
BLUE GILL SUNFISH	1" to 8"	1 Mo. to Adult	964,387
CATFISH	2" to 10"	4 Mo. to Adult	417,085
MINNOWS	2" to 6"	3 Mo. to Adult	218,028
BLUE PIKE (LAKE ERIE)	Fry	Fry	54,631,000
WHITE FISH (LAKE ERIE)	Fry	Fry	2,000,000
CISCO (LAKE ERIE)	Fry	Fry	1,530,000
PICKEREL	14" to 18"	Adult	4,849
SUCKERS	2" to 10"	4 Mo. to Adult	10,101
		TOTAL	235,077,092

TROUT—For the first time 4,601,547 were distributed—of this number 1,396,072 were trout ranging in size from 6 to 21 inches, and 3,205,475 fingerling which were planted in the tributary streams.

For the first time in the history of the Commission, it is producing its own brown and rainbow trout eggs from a selected stock which has been built up over a period of years at the Bellefonte Hatchery. This relieves the Board of the uncertainty of the market for this species of eggs.

BASS—The final figures show that the production and distribution of bass was 526,608 in comparison with 167,265 in 1936 and 357,409 in 1937. This is an accomplishment of which we may feel proud. These bass were 4½ months old and ranged in size from four to eight inches. We are hoping this is only the beginning of a splendid production, and that in 1939 we will be able to greatly increase this number.

SUNFISH, CATFISH, SUCKERS—Arrangements have been made so that the fellow who takes his boy fishing, spending a few hours along some of our lakes and streams will be given a real break by tremendously increasing our production of these warm water fish.

TANK TRUCKS--Distribution methods have been revolutionized by the construction of 15 transportation tanks, with 11 more in the making. They not only transport fish in much better condition but will materially cut the costs over the old system. One tank equals three of the old truckloads when transportaion pails were in use.

CONSTRUCTION PROGRAM TO INCREASE PRODUCTION—The upper and lower Spring Creek Projects have now been completed, which provides the Board with what it believes the largest trout and bass hatchery in the country.

A new development has been started at Pleasant Gap which will add 35 additional ponds.

The Huntsdale Hatchery is rapidly nearing completion and of course has been in trout production for several years. There are now available 130 ponds of different sizes which can be used for trout or warm water fish culture.

Additional work is being done at practically all the hatcheries so that the production of bass and warm water fish will be greatly increased.

DEATH OF DR. WILLIAM C. KENDALL

The older employees of the Bureau of Fisheries learned with deep regret of the death of Dr. William Converse Kendall, formerly Senior Ichthyologist, on January 28, 1939 at Mobile, Alabama.

Dr. Kendall graduated from Bowdoin College in his native state of Maine in 1885 and a few years later received the degree of Doctor of Medicine from Georgetown University, Washington, D. C. On the fiftieth anniversary of his graduation, Bowdoin College again honored him with the degree of Doctor of Science.

On February 4, 1889 Dr. Kendall entered the service of the Bureau of Fisheries and, except for the period from October, 1921 to July, 1923, served continuously on the scientific staff of the Bureau until his retirement on June 30, 1932.

During his more than forty years of service with the Bureau of Fisheries, Dr. Kendall achieved distinction as one of the most eminent of American ichthyologists and as world authority on salmon and trout. His investigations, however, as naturalist on the Bureau of Fisheries schooner GRAMPUS and on the steamer FISH HAWK along the Atlantic and Gulf coasts of the United States included a wide range of scientific projects.

During the few years that he was employed as a member of the staff of the Roosevelt Wild Life Forest Experiment Station in New York, he carried on investigations on fresh water fishes other than the trouts and salmons. In the latter field, however, he was pre-eminent, making important contributions to scientific fisheries literature as well as practical ones in the field of fish culture.

In his later years Dr. Kendall also made expeditions to the Arctic Region to Green land under the auspices of the National Geographic Society and later to Baffin Land to collect fishes from these remote regions.

On his retirement from the Bureau of Fisheries Dr. Kendall returned to his birthplace of Freeport, Maine but he has since traveled widely in the United States. It was on a trip to the South for the winter that his final illness overtook him at a hospital in Mobile, Alabama where he died at the age of 78. He is survived by a daughter, Mrs. Harrison Warner.

(Reprinted from the "Fisheries Service Bulletin" No. 285, February 1, 1939).

REVIEWS

THE IMPROVEMENT OF LAKES FOR FISHING: A METHOD OF FISH MANAGEMENT

By Carl L. Hubbs and R. W. Eschmeyer,
Institute for Fisheries Research, University of Michigan

MARKED INCREASES in the number of anglers in the past two decades without any corresponding expansion of fishable waters have stimulated great interest not only in maintaining fish yields in inland waters but also in projects designed to raise the yields to maximum carrying capacities. For more than half a century, the standard method of aiding fish production was the stocking of lakes and streams with hatchery-reared young fish. In general little or no attention was given to the environmental conditions that obtained in the waters that were stocked until recent years. More and more consideration has been given to various factors that have some influence on fish production in natural waters during the past decade. Up to the present time, such factors as shelter and breeding conditions have been emphasized.

The senior author of this bulletin has been chiefly responsible for the development of devices designed to improve environmental conditions in these respects; he is also responsible for trying these devices out on a large number of Michigan lakes. These experiments and the broad ichthyological knowledge of the authors constitute the fundamental background of the book.

Lake improvement is defined as the creation and maintenance in lakes of conditions which favor the propagation, growth and yield of inland lake fish. The general

requirements for the successful production of fish are considered first; these include the physics and chemistry of the water, such as temperature, dissolved oxygen, hardness, depth, spawning conditions, suitable shelter and food supplies. All these subjects are more or less fully discussed, especially with reference to their general bearing on fish production under optimal conditions. The spawning habits of the different species of fish vary widely, for example, and successful reproduction, therefore, depends upon meeting the diverse requirements either naturally or artificially. Food is also a vital factor, so that fish production is substantially proportional to the food supply in the various types of water.

The second, or main, section of the book (pp. 49-201) deals with the construction of brush, log and other artificial structures designed to serve as shelters for fish and their installation in suitable locations. Also the planting of large aquatic plants, which will furnish natural shelters and feeding grounds, is discussed, as well as devices for bettering the spawning conditions. The use of fertilizers is recommended in certain types of lakes for the purpose of increasing the food supply. Methods of aerating the waters of shallow lakes in winter where there is frequently a heavy winter-kill due to the lack of dissolved oxygen are included in this section as well as the control of fish movements, the handling of fish populations showing stunted growth, the removal of excess rough fish, controlling predators and the treatment and prevention of diseases. The final chapter deals with the praciticability of lake improvement and its place in fish management. This is followed by an annotated bibliography of 18 pages. The book is a valuable contribution to that phase of aquiculture which is concerned with the production of fish, and it fills a great need in this important field of water utilization.

C. Juday
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